Volume 28 August, 1942 *Number 8*

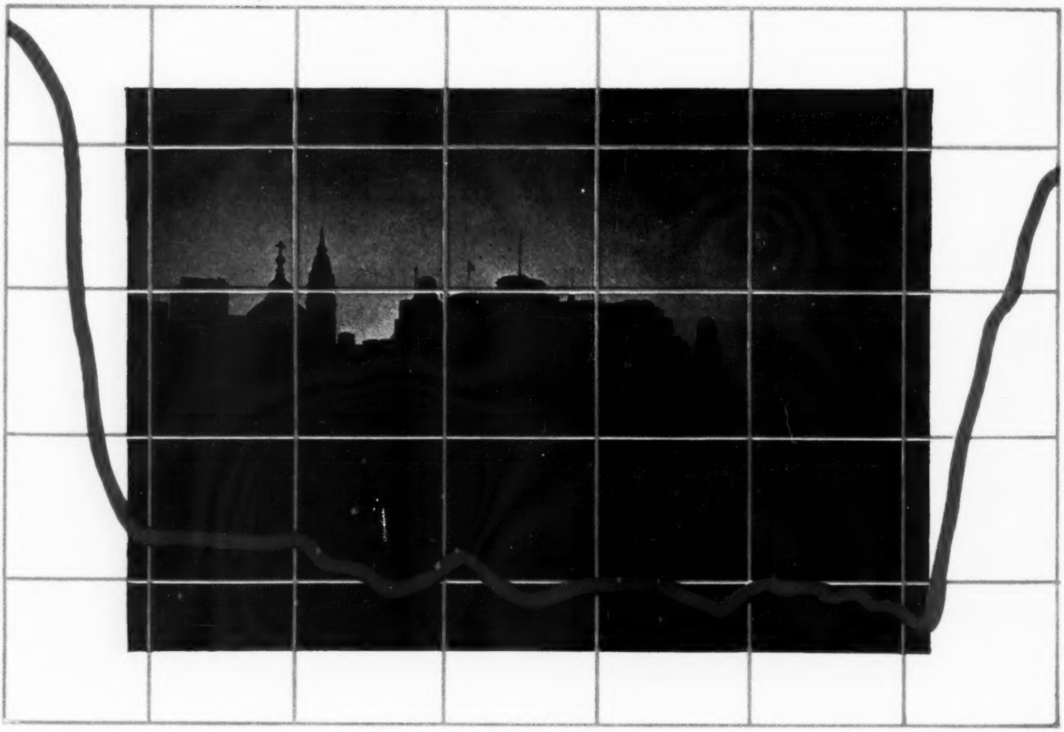
Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

The Cost of Shutdown

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS



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The Texas Company, 135 East 42nd Street, New York City

Vol. XXVIII — August, 1942 — No. 8

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The Cost of Shutdown

INDUSTRY at war has gone through numerous changes during the past year. Probably it will go through many more. These changes from "business as usual" procedure have been required by the need for full-time, twenty-four hour operation, increase in machine speeds, re-tooling in order to build military materials and plant expansions. Production, the essence of the entire defense program, is contingent upon speed. This means that machinery must be operated today as never before. By the same token, it must be maintained and lubricated as never before.

When a hot bearing or gear failure occurred in the good old days prior to 1940 it meant added expense, but nobody really suffered, and the cost was usually absorbed in the maintenance account. Perhaps the lubricating engineer convinced the management that more careful study of lubrication would have prevented the failure. Generally they agreed and when the parts were replaced a test might be run—using perhaps a number of lubricants successively. Test data was recorded on each, such as bearing temperatures, oil inlet and outlet temperatures and load conditions. Then periodically the oil was sampled and subjected to laboratory analysis to note any change in characteristics. If means of reconditioning the oil during circulation was available, the amount of impurities or foreign matter accumulated was also recorded and analyzed.

This was a very helpful procedure. The plant management learned a great deal about the value of dependable lubrication; the Petroleum Industry learned how to improve their lubricants to conform with changes in machine design. It built up an invaluable background of data which has become most useful today; for it is no longer practicable to use operating machinery as a proving ground. Final decisions must be made as to lubrication now—not after several weeks of careful testing.

It must not be inferred that shutdown for mechanical reasons always involves faulty lubrication; materials may sometime fail for purely natural reasons. Then, of course, there are the routine shutdowns for adjustment, inspection and cleaning purposes. Between these periods, however, production machinery must function today more dependably than ever; in other words, unexpected shutdowns must be eliminated. Lubrication is the most positive adjunct to this requirement.

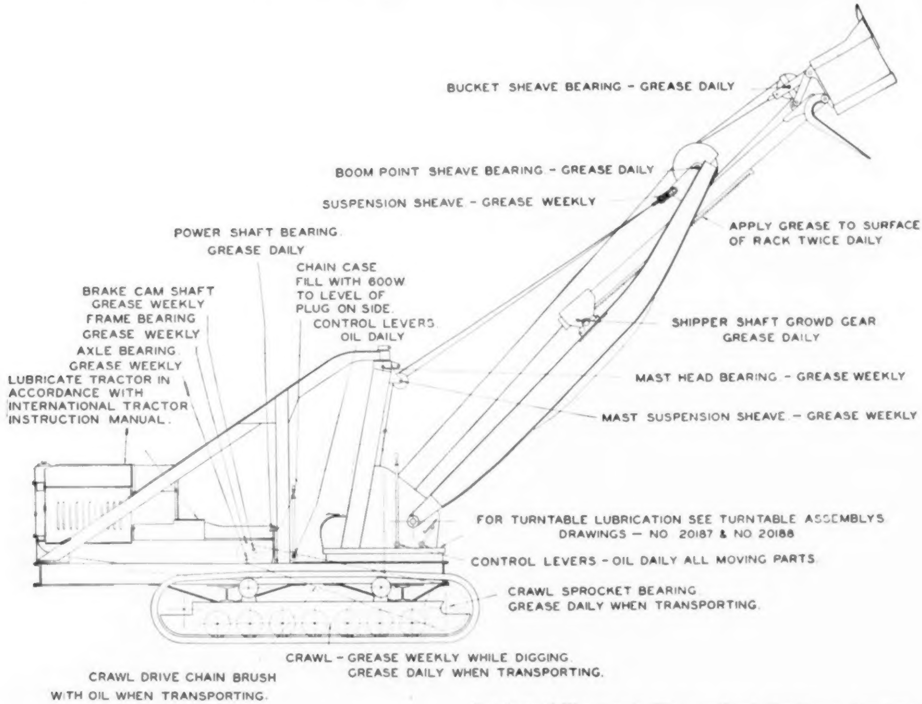
Any shutdown, regardless of the cause, can be figured in dollars and cents, based on the value of the materials being produced and the amount of time lost through idle labor. Today, however, it is not too fantastic to figure the cost of shutdown in terms of planes or tanks per day. Every builder of parts is involved regardless of their size, if they contribute to the assembly of the finished mechanism.

RELATION TO LUBRICATION

Shutdown, on account of lubrication, can be due to too much or too little; to the use of poor quality lubricants; or the use of the wrong grade of lubricant for the operating conditions. Insufficient lubrication is less likely to occur on modern production or power machinery than over-lubrication, for the reason that means of control, methods of circulation and systems of alarm have been so thoroughly coordinated. Consequently, when a condition approaching boundary or starvation lubrication is impend-

ing on machinery equipped for circulated lubrication it is made known automatically before it becomes evident by increase in bearing temperatures, or by actual failure of any of the operating mechanisms.

On many systems of this type, it is possible educational programs must be carried on. This is all the more important where speed-up operations prevail, for casualties on the production line hurt just as much as casualties in service. The net result is loss of man-power and retarded production.



Courtesy of The Austin Western Road Machinery Company

Fig. 1—Lubrication chart for an Austin power shovel showing frequency of application and type of lubricant for each part.

for the operator to give his machinery just a little more oil or grease to be on the safe side. This is permissible within reasonable limits. But unfortunately the amount of over-lubrication cannot always be accurately controlled. If practiced to excess it may lead to undue waste, expense, fire hazard and danger to the plant personnel.

Obviously waste will be costly; generally it is unwarranted. But more important than the actual cost of the lubricants which may be wasted through over-lubrication is the effect which this may have on personal safety and fire hazard. Unless machinery is surrounded by a suitable base, or means to catch and conserve dripped oils, a sloppy condition will result to involve hazard should the operator slip or fall, and come in contact with moving parts which are not completely guarded.

Such conditions may be found in some part of every plant, especially where lubrication must be controlled more or less by individual operators; some will be bound to be careless at times, even with the best of intentions. So,

In order to most effectually control waste of lubricants, the means of lubrication must be thoroughly understood. This requires study of the lubricating equipment, the limitations and constructional details, the requirements of the operating mechanisms of the machinery and the adaptability of the lubricants being used or considered.

Waste of lubricants on machine parts which can be effectually enclosed or protected is related to the means of lubrication. In other words, by judicious selection of a method of application whereby the flow of lubricant can be controlled, the possibility of waste is reduced. In the handling of fluid oils, circulating systems or mechanical force feed lubricators are most effectual; for greases, centralized pressure systems permitting measured feeding of lubricant according to the bearing requirements, serve the same purpose.

METHODS OF LUBRICATION

The trend in modern machine design is to lubricate every part mechanically. In other

words, to eliminate the oil can wherever possible. At the same time, bearing housings and gear or chain casings are built with more effectual seals which will prevent both escape of oil or grease, and entry of non-lubricating contaminants. As a general rule, the design is planned according to the expected operating conditions. No one type is best for every service, although force feed or pressure lubrication have proven to be highly flexible, and adaptable to a wide variety of operating and constructional conditions. Any form of lubrication must be positive and the lubricant used must be capable of developing and maintaining a protective film which will withstand the operating pressures. This requires selection of quality products, for controlled lubrication calls for oils and greases which will give maximum protection when delivered in minimum quantities.

In the application of pressure lubrication to insure that the machine shall be supplied with the right amount of lubricant from the first move, an attachment or crank can be installed on the lubricating system so that all the pipes and bearings can be primed by manual operation of the lubricator pump. The same objective can be attained by installing check valves in the delivery pipes as close as possible to the outlets. Check valves prevent loss of oil or the lubricating piping becoming drained when the machine is idle and the lubricator is not functioning. In other words, there is oil available in the delivery pipes for immediate circulation when operation is resumed.

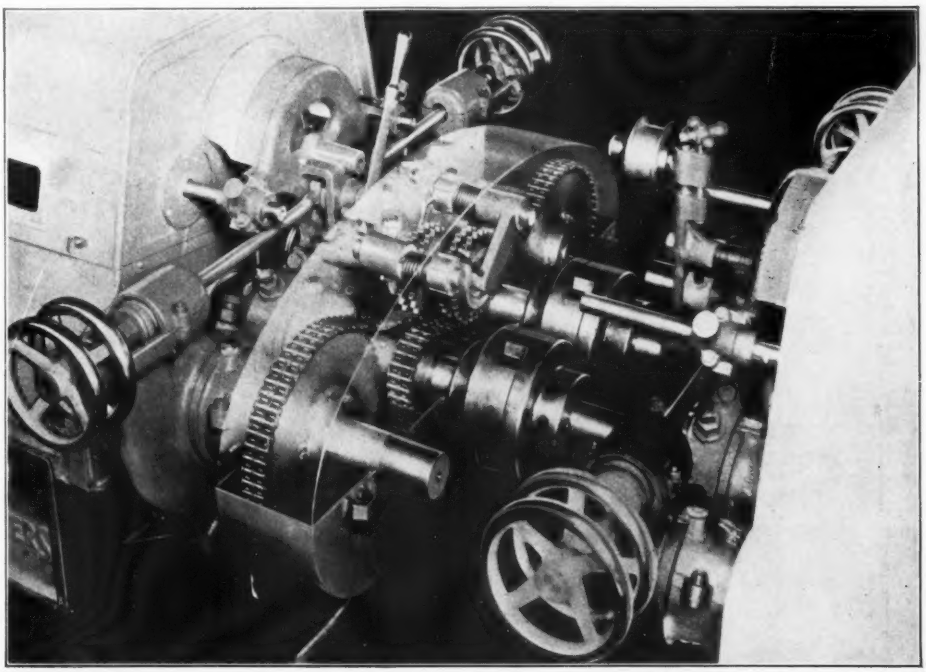
INDICATIONS OF WEAR

The general indications of such wear as may result from impaired lubrication due to abrasive-contaminated lubricants, will be overheating and noise.

In Bearings

Increase in the operating temperature of a bearing can safely be regarded as a positive indication of the occurrence of abnormal solid or semi-solid friction due to more or less actual contact between the bearing elements or the presence of solid foreign matter within the clearance space.

Pronounced noise, however, usually will occur only where wear has been excessive and continuous over a considerable period of operation. In such instances it will be due to marked increase in the clearance space, which will enable the shaft or journal in question to develop an appreciable amount of lateral motion in its rotation. Then a pounding noise results. This action may become decidedly serious, for the bearing metal may often be pounded out of place, temperatures may rise even to the extent of melting this metal, and the resultant



Courtesy of Diamond Chain & Manufacturing Company

Fig. 2—Showing the type of enclosure used for double strand roller chain differential drives applied to grain milling machinery. By "differential" is meant the intentional difference in peripheral speeds of the processing rolls.

misalignment of shafting may impair the operation and increase the power consumption of adjacent (connected) machinery to a marked degree. Ultimately the machine must be shut down.

It is impossible to overcome such a condition by simply resorting to a heavier bodied lubricant. To a certain extent, the increased viscosity will enable the formation of a lubricating film of greater thickness. But it cannot compensate for the wearing action of abrasive foreign matter. Just as long as the latter can gain entry, wear will occur, regardless of the lubricating ability of the oil or grease being used.

The obvious solution is, therefore, to study constructional and operating conditions to determine how and to what extent such abrasive foreign matter is gaining entry. Then means of prevention should be provided. In some instances it may require the installation of better sealing media. In others, merely resorting to more improved means of lubrication or the substitution of grease for oil will solve the problem.

In Gear Sets and Chain Drives

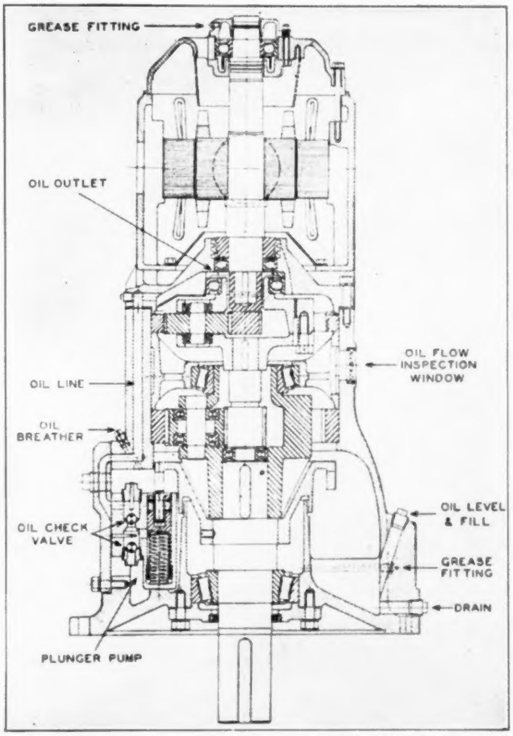
Noise is an indication of wear, in gears and some types of chains. As a general rule, there will be considerably more possibility for ventilation than prevails with the average bearing. In consequence, increase in operating temperatures usually will not be as marked, even in extreme cases of faulty lubrication of gear teeth or chain link connections, for radiation will serve as an effective means of temperature reduction.

Furthermore, whereas it is practicable in many cases to test the temperature of a bearing by hand, with a gear or chain this practice would be hazardous, and even, if possible, would be no criterion of the probable actual temperature at the wearing surfaces.

Development of noisy, clanking operation, however, is a decidedly positive indication that a gear lubricant especially is not functioning as it should, in the prevention of metallic contact and solid friction.

In gear sets there will be periods over which the lubricant will be inactive, for actual friction between the teeth will only occur when they are in mesh. To a somewhat less extent the load imposed upon a chain link connection will also be decreased over the period of slack operation.

Chain lubrication, on the whole, is akin to bearing lubrication as to the requirements which will be imposed upon the lubricants. There is, however, more chance for lubricant to be thrown off from a chain link than from the average line shaft, engine or industrial machine bearing, unless the oil is applied to the inner surfaces of the chain, preferably on the edges of the link plates; then centrifugal force assists capillary action in accomplishing effective lubrication.



Courtesy of Philadelphia Gear Works

Fig. 3—Lubrication details of a vertical double reduction motor gear unit. Note the dry well design of the slow-speed shaft extension. Oil is kept out of this well by an umbrella shield.

The effect of centrifugal force must be especially considered in the lubrication of exposed or semi-enclosed chains. Centrifugal force will, of course, be greatest during the period of articulation or bending, as the chains pass over their sprockets. At such times, any lubricant on the outside surface of a chain may be thrown off, although this will depend upon the cohesive ability of the lubricant and the peripheral or surface speed of the sprockets.

So, there are two primary steps which must be followed normally in the safeguarding of driving chain lubrication, viz.:

1. The selection of a lubricant of adequate viscosity, commensurate with the manner of housing and the method of application, and
2. Application of this lubricant over the inner or more active wearing surface, in order to insure as complete penetration as possible to the link connections before the lubricant has a chance to work its way

to the outside surface of the chain from which it may be thrown off.

Of course, these points will apply more strictly to the exposed or semi-enclosed chain drive, i.e., the installation wherein there is but little or no provision for automatic lubrication. Where a driving chain is subject to a constant supply of lubricant as is the timing gear drive in the automotive engine, or those enclosed industrial chains which are fitted with oil pumps and suitable piping for circulation of oil from a base reservoir, maintenance of lubrication is normally positive, and only requiring of an adequate supply of properly refined lubricant.

A carefully designed housing is a most important feature in the safeguarding of lubrication of any chain. By virtue of the link construction the wearing effect of abrasive foreign matter may rapidly become very serious.

Entry of such dust, dirt or metallic particles as may lead to wear through contamination of the lubricant must be prevented. The oil-tight housing serves the purpose, and it should be used wherever operating conditions may be severe. Then periodic checking of the oil level becomes just a routine precaution.

MAINTENANCE OF THE MOST EFFECTIVE LUBRICATING VISCOSITY

A considerable load will be imposed upon any lubricant wherever it may be called upon to function over a wide temperature range, for temperature has a direct bearing upon the operating viscosity, or the ability of an oil to maintain a lubricating film of sufficient body to prevent metal-to-metal contact between the moving or wearing elements. Where high internal temperatures may be encountered, cooling of such parts as the cylinder walls of the internal combustion engine, or the pistons of large Diesel engines, will be customary, and essential to proper operation.

Methods of Cooling

Water is the most common cooling media involved in connection with the internal combustion engine or the average industrial bearing. On the other hand, air-cooling has been employed to some extent on certain automotive engines, and especially on the radial type of air-craft engine. Oil is also used for piston cooling purposes in certain Diesel engines.

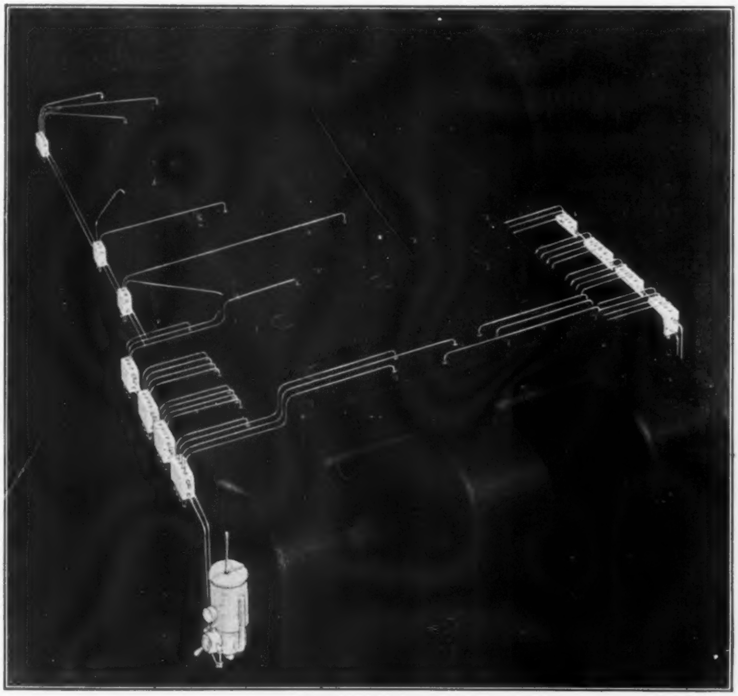
Water as a Cooling Medium

Water is possessed of certain distinct advantages as a coolant for industrial and automotive equipment. In brief:

1. It is available in virtually any quantity in most localities.
2. It is cheap and can be economically handled.
3. It has a high cooling effect by reason of its high specific heat or, in other words, ability to take up heat.
4. Frequently no precautions are necessary in regard to storage or the disposition of waste.

On the other hand, water has a distinct disadvantage in that should leaks develop between the cooling and lubricating systems, undesirable contamination of the lubricant would result. The extent to which this might be detrimental to subsequent operation would depend upon the degree of refinement of the oil, and the design of the machine.

In the steam turbine, where very high quality oils are used, water contamination is a very serious matter. So steam turbine oils must be



Courtesy of The Farrel Corporation

Fig. 4—Showing the piping and valves of a manually operated centralized system of lubrication applied to a forging machine.

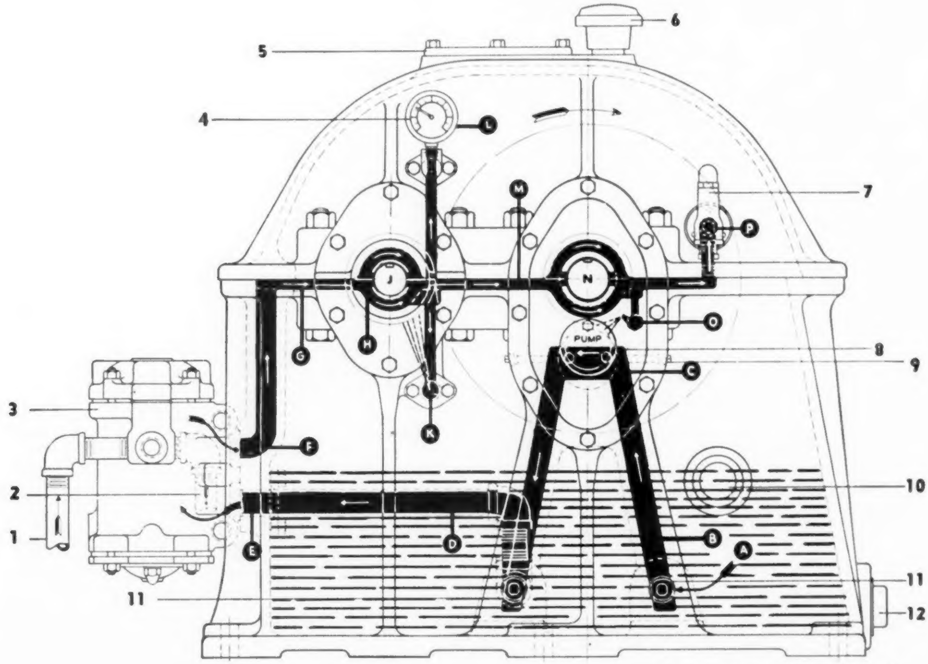
specially refined and have the least possible tendency to emulsify with water, for emulsification and subsequent agitation in the presence of air accelerates sludge formation. Sludge is non-lubricating, and frequently sufficiently viscous and sticky to cause obstruction of oil lines, bearing grooves or other parts of the lubricating system. Obviously, this would impair lubrication, for circulation of the oil would be retarded.

Any reduction in the rate of oil circulation will also decrease the cooling ability of the oil. This is, of course, only a partial function of the lubricant, but if circulation is maintained at a sufficient rate it will materially aid in reducing bearing temperatures, particularly at the wearing surfaces where over-heating would be most detrimental.

Air Cooling

The degree of success which can be attained by air cooling will depend upon the provisions for complete circulation of air to the heated parts, to bring about adequate heat transfer.

As a general rule, air cooling as an adjunct to lubrication is most practicable in connection with moving machinery, such as the airplane engine. Here a natural draft is developed by the passage of the engines through the air. On the other hand, it is practicable to develop artificial draft by means of fans or blowers.



Courtesy of The Falk Corporation

Fig. 5—The oil circulating system for the Falk Type Q high-speed gear unit is both simple and positive. The oil passes directly from the sump to the pump through the cooler to the sprays and bearings and back to the storage tank. The oil enters the lubricating system through the intake port A and passes up the short suction line to B to pump inlet C. At the pump it is forced through the discharge line D where it enters the cooler at E. Properly cooled, it leaves the cooler at F and is forced into the enclosed passage G and H, part of it entering the oil inlet to bearing J. It continues its course into the spray manifold K for gear lubrication, and to the oil pressure gauge L. Part of the oil enters the oil passage M, passes to the low speed bearing N, pump-gear spray O and pressure relief valve P.

1. Shows the Water Inlet, 2. Water Outlet, 3. Cooler, 4. Pressure Gauge, 5. Inspection Cover, 6. Air Vent, 7. Relief Valve, 8. Lubricating Pump, 9. Prime for Pump, 10. Oil Level Sight, 11. Discharge Port and Inlet Port (identical to permit changing connections for reversal of rotation), 12. Drain Plug.

Unless this draft is led directly to the parts to be cooled, however, much of its intensity and cooling value will be dissipated to the surrounding atmosphere.

As the airplane engine travels at a high rate of speed through the air, it has been a most ideal subject for the utilization of air cooling. The radial engine received the most attention in this regard, due to the arrangement of its cylinders and the fact that each cylinder can be surrounded with an arrangement of fins for heat dissipation.

Oil Cooling of Diesel Engine Pistons

The use of oil as a cooling medium and as an adjunct to lubrication has received most attention in the Diesel engine industry. For this purpose, mineral oils possess the most satisfactory characteristics, in that they will show the least tendency to gum or develop heat-

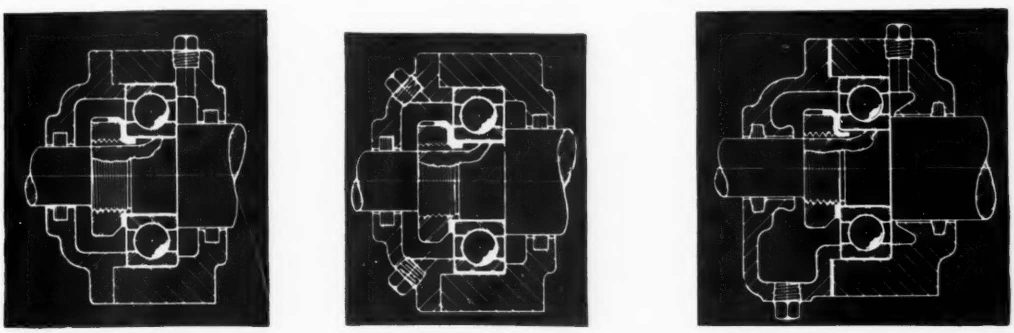
resisting deposits, especially when subjected to wide temperature variations.

Mineral oils have a considerably lower cooling ability than water, due to their low specific heat. On the other hand, they possess the distinct advantage, in that, should leakage develop, the quality of the lubricant normally will not be materially lowered, especially if a good quality oil is used for cooling.

This is very important in the operation of the modern Diesel. Construction of virtually all the large high speed engines requires cooling of the pistons. This can, of course, be accomplished by either water or oil. The use of the former has already been mentioned. Oil cooling in turn, is being given equal consideration, for it is added insurance that lubrication will not be impaired should the cooling medium leak into the lubricating system. Oil cooling, however, is limited by the design of the piston. This must be such as to insure a continuous turbulent flow of oil in order to prevent, as far as possible, the formation of heat-resisting films along the walls. Should such films develop, carbon deposits may accumulate, especially at the more highly heated parts of the piston.

Oil-Cooled Heat Exchangers

Mineral oil has also been used as a cooling medium in connection with heat exchanger types of lubricating oil coolers. Such equipment is adaptable to steam turbine service; for example, where a considerable volume of oil must be continuously cooled. Here again, mineral oil, even though it may not possess as great a cooling ability as water, protects lubrication more effectively should leaks develop within the cooler.



Courtesy of The Fafnir Bearing Company

Fig. 6—Various types of ball bearing design. View at left has no drain or vent provision and requires a grease which will not channel, aerate or oxidize. Center view provides for draining. View at right is most desirable as it provides a drain, also means for forcing fresh grease through the bearing element and old grease out. This design permits higher speeds, also only a limited amount of grease remains in the bearing.

Handling the Cooling Media

Unless water can flow by gravity through a cooler, or be piped directly from city water mains, some means of pumping must be employed.

A number of types of pumps can be used for this purpose, depending upon the size of the installation and the volume of coolant to be circulated. Under general conditions of industrial plant or engine operation, the gear, rotary or centrifugal pump is used. The reciprocating piston or plunger pump is, of course, also adaptable, but since it will normally require steam for operation, it is seldom used in connection with oil cooling.

Circulating pumps can be driven either directly by the machine which they are to serve, by an independent electric motor or some other means of power transmission. In the automotive engine, a gear pump is used driven by belt or chain connection from the main shaft. Where industrial bearings are involved, or where a more considerable volume of cooling media must be handled, independent drive is most adaptable.

Pump Lubrication

Where a pump is built into the machine which it is to serve, it will normally be designed for handling oil, the function of which is both to serve as a lubricant and a coolant. At the same time, this oil serves to lubricate the pumping elements.

Where either a centrifugal or rotary type of pump is designed for handling cooling water, it will be installed adjacent to the main machinery, but usually driven directly therefrom through gear, chain or belt connection.

In pumps of this type it will, of course, be essential to lubricate the bearings, for the pumps cannot be expected to function effectively as an aid to lubrication if they are not, in turn, properly lubricated.

SPEED

Speed is the essence of production today.

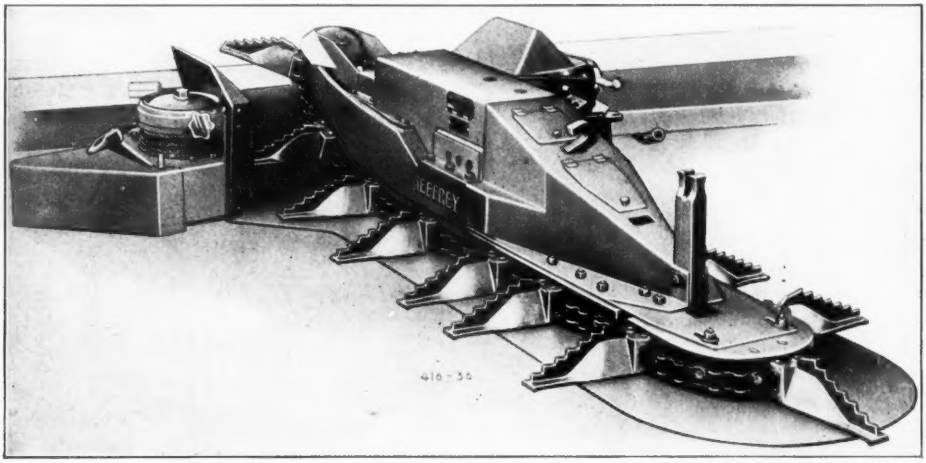
Speed, of necessity, places more or less of an overload on machinery, also on lubricants. In theory, increase in speed permits of using lubricants of greater fluidity. This is advisable because as the speed is increased the natural pumping action, which is developed by the turning of the shaft, is increased. Furthermore, lighter-bodied lubricants develop less internal friction; consequently, less temperature when subjected to rapid circulation and agitation. Accordingly, a lubricant suited to a certain range of speed conditions may be unsuited to service where a higher range of speed conditions is necessary due to present-day production schedules.

Any interruption in delivery of the lubricant, or abnormal increase in bearing temperature which might cause a change in the physical characteristics of the lubricant may lead to shutdown.

The rate of shear between the component molecules which make up the lubricating film is of importance as it is increased with increase in speed—conversely, it is decreased with decrease in viscosity. So, while the rotating shaft develops greater pumping action and a lubricating film of more uniform thickness as the center of the shaft approaches the center of the bearing, the increase in shear will result in an increase in internal friction within the lubricant itself, unless the body or viscosity of the latter is reduced accordingly.

The nature or smoothness of the contact surfaces is also a factor. When running steel-on-steel as in the ball or roller bearing, research has proved that the more highly finished the surfaces, the more dependably can low viscosity oils be used in a properly sealed bearing housing. In the sleeve-type bearing, however, the steel shaft should not be too highly finished, as microscopic depressions should still exist to serve as reservoirs for lubricant.

Precision finishing is also applied to driving chain pins and bushings to good advantage where dependable service under increased speeds up to around 8,800 r.p.m. prevail according to the pitch. Here again we are dealing with steel-on-steel where grinding limits of ± .0002 inches on pins and bushings promote exceptional quietness and positive circulation of oils which are fluid at the operating temperature. When chains are well lubricated, even though the speed may be exceptionally high, the rate of wear or pitch-elongation is extremely slow; nor can sprocket wear occur in a well designed drive except as a result of chain wear.



Courtesy of The Jeffrey Mfg. Company

Fig. 7—A Jeffrey conveyor-loader for loading coal from face to conveyor. Link and wire rope protection by lubrication is an important factor in the operation of this machine.

Means of Lubrication

The maintenance of a constant film of lubricant on the contact surfaces of any high speed mechanism will depend upon the provision for automatic lubrication. If oil is delivered by means of a drip feed oiler, wherein the principle is to supply just enough oil to maintain lubrication, should there be an increase in speed, the rate of oil feed must be increased, otherwise there may be inadequate lubrication.

Where automatic force feed lubrication is provided, however, there will always be more oil delivered than is required. Flood oiling, therefore, provides insurance against starved lubrication; it also materially resists the effects of pressure. This is well illustrated by the lubricating system of the pressure-oiled steam turbine bearing. Here, although comparatively high speeds are involved, and unit

bearing pressures are fairly high, if the oil is delivered at from 8 to 15 pounds pressure a product as low in viscosity as 140 seconds Saybolt Universal at 100 degrees Fahr., will maintain adequate lubrication and insure protection of the bearings. Another significant illustration is the plain bearing high speed grinding wheel spindle which can be designed for lubrication by an even lighter oil,—well below 100 Sec. Saybolt Universal viscosity at 100 degrees Fahr.

Flood lubrication is also of advantage in that the excess of oil which is passed through the bearings will remove a certain amount of the heat developed during operation, or received from any external source. The higher the speed the more positive the lubricating film with such a system due to the increase in capillary action which assists the oil in passing through the bearing clearances.

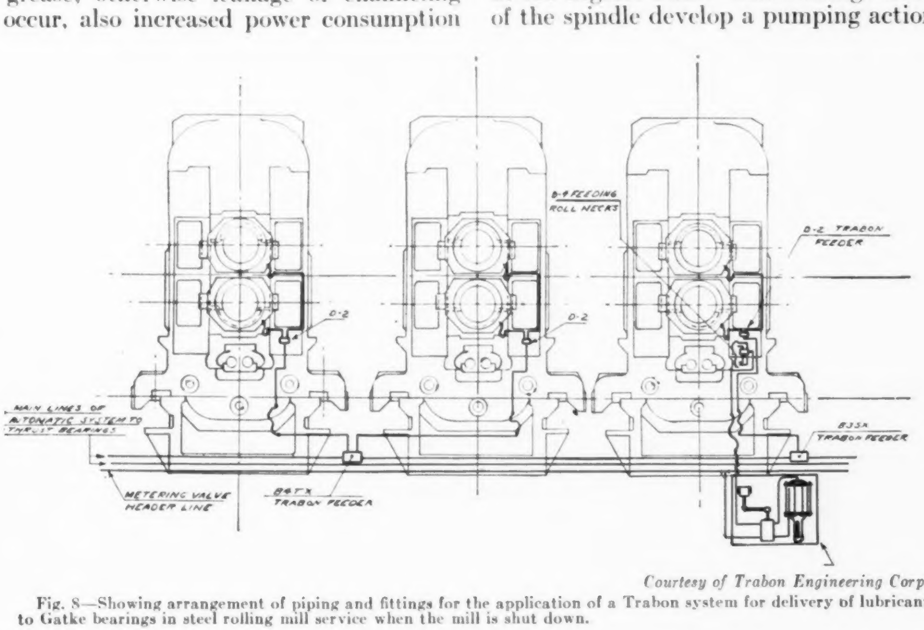
Grease lubrication under high speed conditions is particularly adaptable to ball or roller bearings which are not designed to retain oil. On the other hand, the bearing must still be capable of retaining a comparatively light bodied grease. Provided this is a product of good lubricating value, lubrication will be assured for an extended period of operation with the necessity for only infrequent renewal. The bearing, however, must never be over-charged with grease, otherwise leakage or channeling may occur, also increased power consumption due to drag on the rolling elements. The majority of portable tools and household applications, where lubrication may be so often neglected, are now completely sealed and pre-lubricated by the bearing manufacturer. Such bearings when packed with a high quality grease have a life of several years without necessity for renewing the lubricant.

High speed machinery must always be studied from the viewpoint of the extent to which centrifugal force will be developed and the lubricant thrown from the moving parts. This brings in the relationship between speed and the film strength or adhesiveness of lubricants. It must be especially considered on exposed units. In a housing of oil-tight construction a comparatively fluid oil can be used, especially if it is automatically delivered to the contact surfaces and not merely spread by the rotating parts dipping in a bath of lubricant.

Where the mechanisms are not tightly housed, the viscosity must also be considered. Unless these factors are studied, present day overloads may cause a failure which would result in shutdown. It is the duty of the lubricating engineer to study the installation and make his recommendation accordingly.

Oil-Mist Lubrication

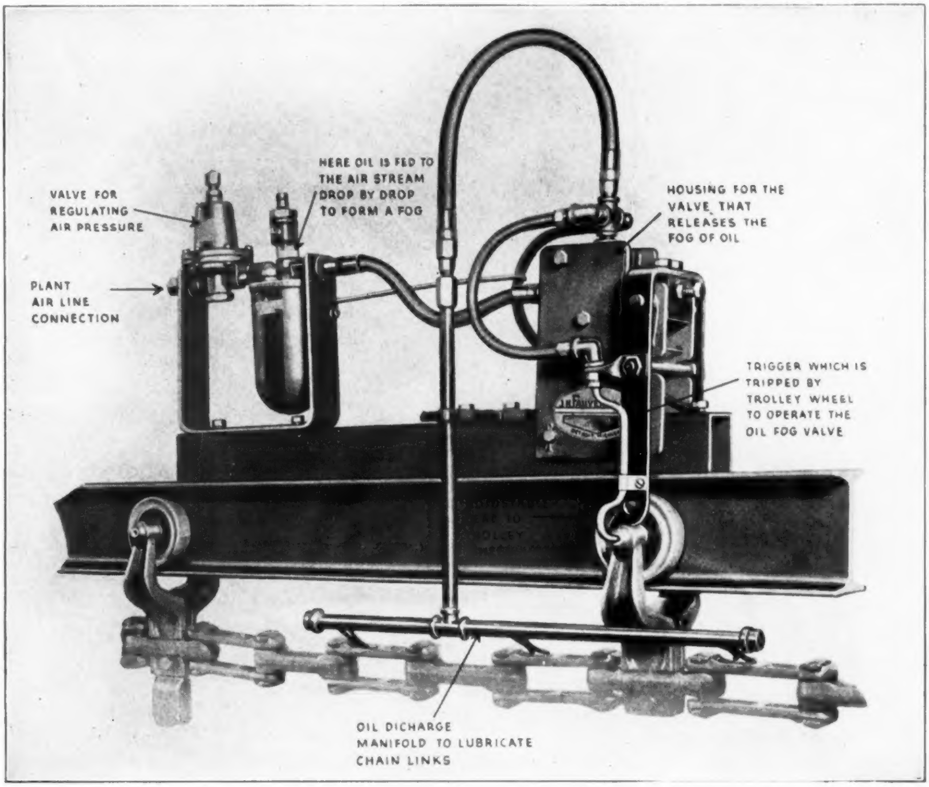
In the application of high speed ball bearings to grinding wheel spindle service where speeds as high as 40,000 r. p. m. may be developed, a method of oil-mist lubrication has been perfected using very light viscosity spindle oils ranging around 60 seconds Saybolt Universal at 100 degrees Fahr. The bearings on each end of the spindle develop a pumping action which causes the oil to circulate continuously through the hollow spindle. External slingers effectively prevent entry of any outside dirt or liquid. By designing the bearing housing so that it will retain oil effectually, oil-mist lubri-



Courtesy of Trabon Engineering Corp.

Fig. 8—Showing arrangement of piping and fittings for the application of a Trabon system for delivery of lubricant to Gatke bearings in steel rolling mill service when the mill is shut down.

cation has proved to be dependable, capable of protecting precision-finished ball bearings for lengthy periods, and keeping high speed grinding machines in continuous service. This is most important as much of this class of machinery is used today in the finishing of ball bearings for aircraft control mechanisms and military automotive engines.



Courtesy of J. N. Fauver Co., Inc.

Fig. 9—Application of an automatic conveyor lubricator showing controls, and leads to conveyor trolley wheels and chain links.

PRESSURE

Pressure may interfere with lubrication if the viscosity or consistency of the lubricant is not sufficient to withstand any squeezing out action which may be developed due to the construction of the moving parts. Then considerable damage may result through lack of proper lubrication. So pressure also must be considered in the study of any lubricating problem, the preparation of a lubrication recommendation and organizing to prevent shutdown.

Under average conditions the greater the operating pressure between any two contact parts, the heavier or more durable must be the lubricating film in order to prevent metal-to-metal contact. This holds true whether bearings, gear teeth or cam mechanisms are involved. The most usual effect of pressure will be a tendency toward squeezing out of the lubricating film from between the contact surfaces. In a bearing this can be counteracted by providing adequate bearing area and proper grooving.

On some types of mechanisms the danger of interfering with lubrication by pressure can be partially prevented by enclosed construction, to enable the parts to operate in a bath or flood of lubricant. This is particularly helpful where the period of maximum intensity of the pressure is relatively brief. In other cases, pressure can be met with pressure, the lubricant being maintained within the clearance spaces under pressure developed by some form of pumping device. This is not practicable, however, on open-ended bearings.

Selecting the Lubricant

Obviously, the nature of the lubricant must depend upon the means of lubrication available; the operating conditions as already mentioned which include speed, temperature and pressure; and the provisions for lubricant distribution such as bearing grooves. By reason

of the size, duty and bulky nature of the moving parts of machinery which customarily involves high pressures, it is usual to provide for some form of positive automatic lubrication by means of either grease or oil. Greater convenience should result thereby, with frequently marked savings in labor due to reduced amount of attention. Typical examples are steel rolling equipment, the metal press, the cement kiln, the milling machine and the news press.

Significance of the Operating Pressure

Wherever heavy duty machinery is involved, it is important to remember that we are chiefly concerned with the "operating pressure." In other words, when the rolling mill or metal press are idling, the pressures which may be developed between the gear teeth or upon most of the journal or shaft bearings are not too severe. So, idling pressures seldom present a problem.

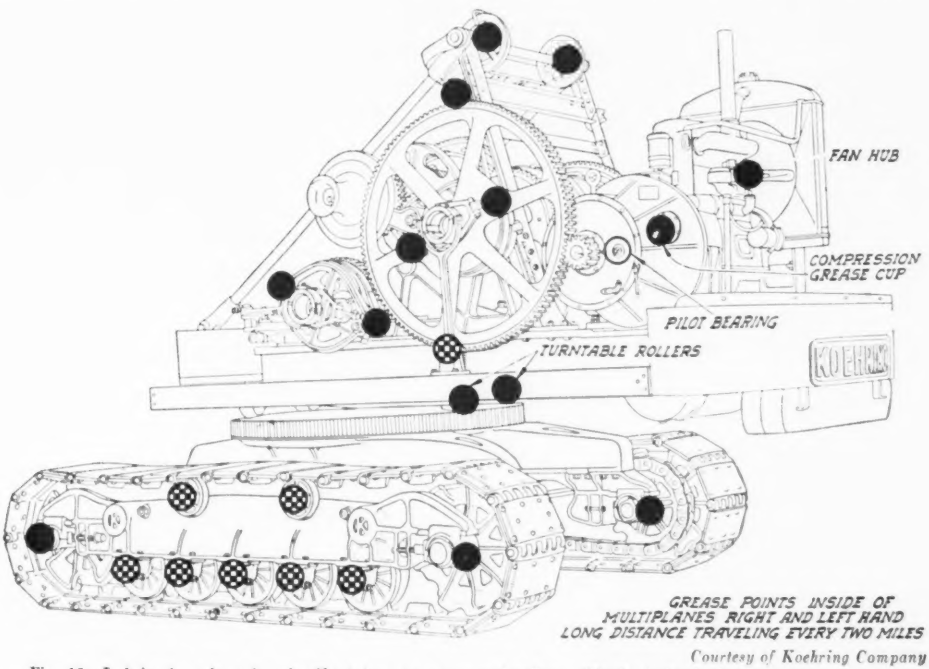
In service, however, the high pressures which must be exerted upon the raw materials in the formation of finished or semi-finished products will react back with considerable intensity upon practically all the moving parts of the machine. Not always with the same intensity, to be sure, for this will depend upon the size or relative importance of the respective parts. In general, however, reaction or back pressures are much higher than idling pressures; hence they may become a potential cause of lubricating difficulties and shutdown.

Careful selection and intelligent application of the lubricant is the most effective way of counteracting operating pressure. Mention of the viscosity, adhesiveness and film-strength has already been made. On certain machinery this may, of course, result in abnormal internal friction within some lubricants when the machine is idling, but it is better to prevent metal-to-metal contact under peak load conditions than to reduce power consumption. This is particularly true in service where the idling periods should be reduced as much as possible.

Importance of Viscosity

As the viscosity is a measure of the relative fluidity of an oil it becomes somewhat of an indication of the ability to withstand the squeezing-out effect of pressure by virtue of the cohesion between the component molecules.

In this regard the space limitations of bearings, in particular, is important. It is not always possible to build the lubricating system so tight in the average heavy duty machine that there are definite space limitations as far as the lubricating film is concerned. So some leakage must be expected. It is reasonable to presume, however, that the lubricant will be delivered under mechanical pressure at a rate exceeding its tendency to leak or pass from the



Courtesy of Koehring Company

Fig. 10—Lubrication chart for the Koehring shovel-crane-dragline. Black circles indicate points to be greased once or twice daily; checkered circles show points to be greased once a week. Engine oil should be changed after every 50-hour run.

bearing. Under such conditions the relative fluidity of the oil may be considerably decreased; a condition comparable to cooling.

This should promote effective lubrication unless it occurs to an extreme, for the existing oil film being under pressure will be more capable of preventing metal-to-metal contact. The oil should never become too sluggish, however, for this might mean that certain parts of the bearing would be receiving practically no oil. On most machinery subject to heavy bearing or gear tooth pressures, the lubricating film will have some place to go. So, even though high mechanical pressure may be involved, the lubricant will still be exposed to atmospheric pressure at the ends of bearings or sides of gear teeth. Hence, the importance of cohesion and film-strength in the interest of maintaining a lubricating film of sufficient body under peak load conditions.

OIL RECONDITIONING

Lubricants, of course, can only function effectively provided that they are kept as free as possible from contamination during service. They are not impervious to entry of foreign matter, nor to mixing with water or chemicals, although with certain grades the extent to which this may occur will depend upon the degree of their refinement. High grade steam turbine oils, for example, will markedly resist emulsification with water, just as properly refined gear lubricants will resist penetration of abrasive matter.

To rely upon the degree of refinement, however, is never positive assurance that such contamination will be satisfactorily resisted. Mechanical means must be provided to prevent the entry of contaminating foreign matter.

The means to use will of course depend upon the design and construction of the moving elements, as well as upon the operating conditions.

Where a considerable volume of oil is involved, as for example in the operation of the steam turbine or Diesel engine, bulk treatment of the oil is practicable, using means for filtration or centrifuging.

Filtration

The modern industrial or power plant oil filter will, in general, provide for combined precipitation and filtration. The oil as received from the lubricating system, etc., is run to a removable strainer box to take out any larger, heavier particles of foreign matter. From the strainer box it generally passes to a heating tray; especially if it is a heavier, more viscous product, in order to promote subsequent precipitation and separation of as much water and sludge as possible. This may or may not involve hot water washing to remove water-soluble acids which may have developed in the oil. If water washing is required, obviously the oil must be subsequently dehydrated. Then the oil passes to the filter compartment.

Centrifugal Treatment

Where a considerable volume of oil is involved, it is also practicable to employ centrifugal treatment for the removal of abrasive or non-lubricating foreign matter. As a general rule, centrifugal purification is a more rapid process than filtration, and quite as readily employed for continuous or batch treatment of turbine or Diesel engine lubricants.

Separation of substances or fluids of different specific gravity can be effectively brought about by centrifugal force, in a comparatively short period of time, due to the intensity of the force involved. As in the case of precipitation, moderate heating is an adjunct to effective separation by centrifugal force, due to the resultant reduction in viscosity of the oil under treatment. The extent of heating necessary would of course depend upon the viscosity of the oil, and to a certain degree upon the amount of contamination. Obviously, a light turbine oil would not require as much heating as a relatively heavy Diesel engine oil.

Separator Construction

The typical centrifugal separator consists of a rotating bowl or cylinder contained within a suitable frame or housing. Oil to be treated is delivered to the lower part of the bowl. When the latter is rotated metallic particles, dirt, sludge, water and oil are separated according to their relative specific gravities, solid matter being thrown to the sides or walls of the bowl. The water and oil are carried upward to be caught in suitable covers which are fitted with spouts for discharge to drain or clean oil tank respectively.

CONCLUSION

In this discussion of lubrication as it may relate to the cost of shutdown, obviously it has been impossible to quote actual figures. Nor would it be tactful. So, we have had to be content to stress the fact that there is such a relationship, furthermore, that it can be counteracted by more careful attention to the controlling factors which affect a lubrication recommendation. It is a form of preventive maintenance, carried out after the means of application has been established. The fact that it is effective is borne out by the ability of production machinery today to perform under production schedules which would have been thought impossible, had they been considered by the designers in the beginning.

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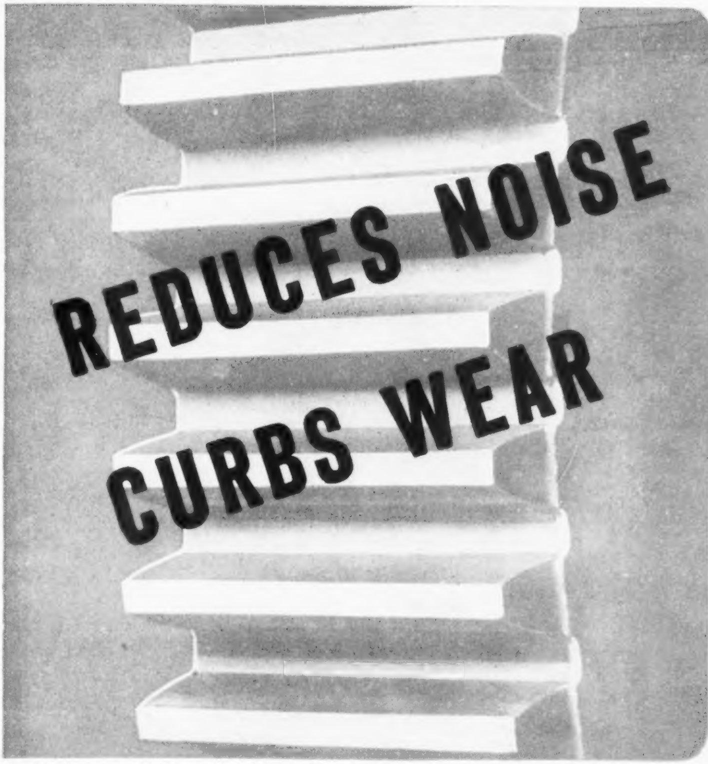
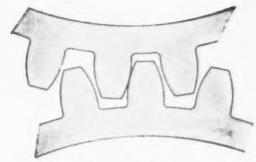
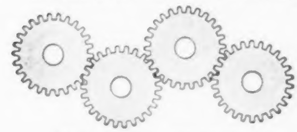
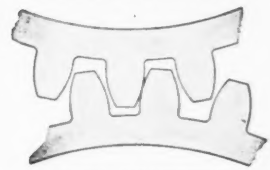




CUSHIONS SHOCK LOADS



FOLLOWS THROUGH



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